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Not My Fault: Afghanistan earthquake another tragic story of weak building materials and vulnerable infrastructure

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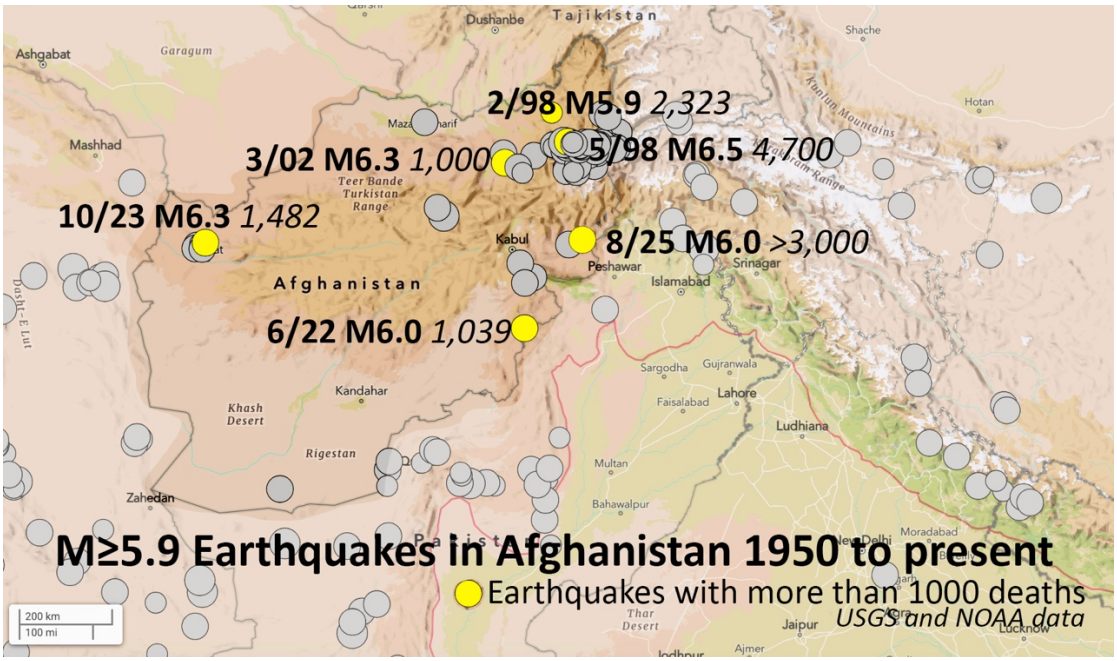

Earthquakes of magnitude 5.9 and larger in Afghanistan and the surrounding area. Epicenters with death tolls of 1,000 or higher are shown in yellow, including the Aug. 31 magnitude 6.0. (Source: USGS and NOAA)

On August 31, a magnitude 6 earthquake struck northeastern Afghanistan. As I write, the death toll is estimated at over 3,000, ranking as the second deadliest of 2025. There are no instruments near the epicenter, but seismologists can learn a lot about earthquakes from instruments in neighboring countries. We know it was shallow, only 5 miles beneath the surface, and on a northeast – southwest oriented thrust fault, the same type of fault as the 1954 Fickle Hill earthquake that I wrote about in my last two columns.

M6 just makes it into the USGS "large" earthquake category, capable of causing damage when centered close to vulnerable structures but rarely catastrophic. In a typical year, there are about 125 earthquakes in the M6-7 range and they don't often make it into the "deadliest of the year" column. The USGS has published no information on the likely fault length and slip, but earthquakes ruptures of this size are usually no more than a few miles in length with slip of less than a foot.

What made the 2025 Afghanistan so deadly? Earthquake impacts, like real estate value, are mainly about location. Magnitude is important, but even the largest earthquakes can cause

minimal impacts when far from population centers. The July 29 M8.8 off the coast of Russia's Kamchatka Peninsula, now tied for 6th place in the list of largest tremors in the instrumental era, is a good example. It was huge, rupturing a fault nearly 400 miles long and over 50 miles in width. Peak slip along the fault was more than 30 feet according the USGS finite fault model, taking about three minutes to rupture.

The Kamchatka earthquake was felt strongly in Kamchatka and in the northern Kuril Islands to the south. The most populous city, Petropavlovsk (population 187,000), was 75 miles away from the epicenter but experienced little damage and only four injuries as a direct result of shaking. There were more human impacts in Japan where a woman died from an auto accident and 21 people suffered from heat exhaustion during the tsunami evacuation.

Magnitude is a logarithmic scale and the Kamchatka M8.8 released roughly 15,000 times more energy than Afghanistan's M6.0. Why were the effects so different? The answer is earthquake characteristics and location. From the size and depth, the Afghan earthquake likely ruptured quickly and produced more high frequency seismic energy than the much larger Kamchatka quake, especially in the epicentral region. High frequency waves, the ones that vibrate quickly and make an earthquake feel sharp, die off quickly as they travel through the earth than the longer period ones. You've probably experienced this with an upstairs neighbor blasting loud music – you mainly hear the annoying bass notes because the treble doesn't make it through the walls.

The Kamchatka earthquake was 22 miles deep and the nearest communities were over 80 miles away. Much of the high frequency energy, ones with periods of a second or less, was weakened by the time the waves hit populated areas. It's this high frequency signal that is particularly damaging to one-story homes and small structures. The rugged hillslopes of Kunar Province in northeastern Afghanistan near the epicenter was dotted with small villages less than 20 miles away. The USGS PAGER loss model estimated nearly two million people lived in areas of 'Very Strong' to 'Violent' ground shaking. In contrast, the PAGER estimate for the much larger Kamchatka earthquake puts the number in the same category as just under 300,000.

Distance and exposed population only tell a part of the story. The built environment in Kamchatka and Afghanistan is vastly different. Kamchatka has modern building codes with standards for reinforced concrete and homes built primarily of wood. Outside of cities, Afghanistan structures are made of mud and stone, the only building materials readily available. Unreinforced structures built of heavy materials can be deadly in even modest ground shaking. The earthquake added a further insult by occurring just before midnight local time in Afghanistan when almost everyone was inside their homes sleeping.

This isn't the first time that an earthquake in the magnitude 6 range has caused devastation in Afghanistan. In the last 30 years, 32 earthquakes have caused fatalities in the country, ten with death tolls greater than 100 and six topping 1,000. The largest of the 1K events was 6.5 in 1998 with a death toll of 4,700, but even a relatively modest 5.9 in 1998 makes the list with over 2,300 fatalities. There have been three earthquakes in the M7 range in that same time span, the largest a 7.5, but they were centered at the extreme north of the country, and none were as deadly as some of the M6s.

Earthquakes in Afghanistan and nearby areas of Pakistan and India occur because of the tectonic setting. It's a region where plates are on the move and the site of the most spectacular plate collision currently in process anywhere on the planet. The Indian subcontinent was once a part of Gondwanaland, the supercontinent consisting of the world's southern continental land masses. Heat trapped under the thick continental crust began to break it apart in the Jurassic about 180 million years ago, separating Gondwanaland into pieces and sending them in different directions.

One piece was the Indian subcontinent which headed in a northward direction. For over 50 million years, India drifted peacefully, unaffected by interactions with other land masses. From magnetic anomalies, it may have been moving at a nearly six inches per year, very fast for plate motion and about twice as fast as your fingernails grow. That all changed around 50 million years ago when India neared Asia.

It's hard to slow down a continent on the move. The Indian subcontinent is massive and had an enormous amount of momentum. Since that first contact, it has plowed into Asia, creating the Himalayan Mountains and the Tibetan Plateau. Today, India has been slowed and is now moving north at only an inch and a half per year, but that is still enough to exert considerable stress, continue to build the Himalayas and Tibetan Plateau, and create a vast network of faults around the perimetry. Afghanistan, Pakistan, India, Bangladesh, Bhutan, Nepal, China, and Myanmar can all trace their seismic hazards to this source.

Alas for Afghanistan, with not only a high seismic hazard but other factors that have exacerbated vulnerability. The landlocked country has long struggled with resource limitations including arable land and forests. For much of its history, its territory has been fought over and subjugated by various empires including Persians, Alexander the Great, and the Mongols. It experienced a brief period of peace and Autonomy in the 1950s to early 1970s when King Zahir Shah led a constitutional monarchy with reforms and a more open society. My brother Mark visited in 1971, easily traveling over much of the northern part of the country and marveling at both the friendliness of the people but commenting on how much of the land seemed locked in the Middle Ages.

That all changed in 1973 with a coup, the Soviet Afghan war from 1979 to 1989, the rise of the Taliban, the post 9-11 American conflict, and a return to Taliban control in 2021. The legacy of these conflicts has left shattered government institutions, deteriorating roads and other infrastructure, discarded mines and munitions, and pariah status in the international community. The Taliban has requested aid from other countries, and the United Nations has sent assessment teams. A number of countries have pledged support, but access is extremely difficult, and outside teams have yet to reach the most affected areas.

The 2025 Afghan earthquake is a lesson in what happens when a society does not have the capacity to construct earthquake resilient buildings, plan for disaster management, and respond quickly to the affected area. But don't get too smug about our own level of resilience just yet. While a magnitude 6 earthquake is extremely unlikely to kill thousands in California, it could kill hundreds if placed in a vulnerable spot. The 2011 M6.2 earthquake beneath Christchurch, New Zealand is a case in point. It was shallow and centered near the downtown where two 1960s era reinforced concrete buildings collapsed, accounting for almost all of the 185 deaths. New

Zealand has a similar mix of construction styles to California and 2011 is a reminder that we still have work to do in the earthquake resilience category.

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt, and an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column or to request copies of the preparedness magazine "Living on Shaky Ground."